Vol. III. JANUARY, 1887. No. 9.

American Meteorological Journal.

A Monthly Review of Meteorology, Medical Climatology and Geography.

TABLE OF CONTENTS.

	PAGE
CURRENT NOTES:	
Snow as a Cause of Cold Weather	389
Arizona Desert Lands and their Irrigation	391
The Imperial Meteorological Observatory at Tokio	394
U. S. Consular Reports	395
Protection from Lightning	395
The Law of Storms in the Eastern Seas	396
Temperature and Rainfall in the Croydon District	396
The Use of Oil at Sea	397
Utilization of Earth's Internal Heat	397
Depths of Fresh-Water Lakes	398
Argentine Meteorology	398
Earthquake Records of the Rocks	399
Review of New England Thunder Storms of 1885	399
Royal Meteorological Society	403
Forests and Floods in Southern California	405
ARTICLES:	
An Investigation of Cyclonic Phenomena in New England. E. WINSLOW UPTON	407
Loomis' Contributions to Meteorology. H. HELM CLAYTON	417
Connection between Meteorology and Terrestrial Magnetism. RICHARD OWEN	426
SELECTED ARTICLE:	
Causation of Pneumonia. Dr. HENRY B. BAKER	430
Additional Current Notes	437

ANN ARBOR, MICH., U. S. A.:
METEOROLOGICAL JOURNAL COMPANY.
19, 21 and 23 Huron Street.

F. A. BROCKHAUS, Leipsic, Berlin, and Vienna, Agent for German and Austrian States.

Single Copies, 25 cents. Per Annum, $2.00. In European Countries, $2.25.

Entered at the Ann Arbor Postoffice as Second Class Matter.

AMERICAN METEOROLOGICAL JOURNAL.

AN ILLUSTRATED MONTHLY

DEVOTED TO SCIENTIFIC METEOROLOGY AND ALLIED BRANCHES OF STUDY.

THE AMERICAN METEOROLOGICAL JOURNAL CO., Publishers and Proprietors,
Ann Arbor, Michigan.

M. W. HARRINGTON.
Director of the Astronomical Observatory, Ann Arbor, Michigan,
A. LAWRENCE ROTCH
Proprietor of the Blue Hill Meteorological Observatory, Massachusetts.
Editors.
K. KITTREDGE, Manager.

PRICE,—IN THE UNITED STATES, - - - - $2.00 per year
" IN COUNTRIES OF THE POSTAL UNION, - - 2.25 " "

Agent for German and Austrian States
F. A. BROCKHAUS, Leipsic, Berlin and Vienna.

The editors solicit communications on all subjects having any bearing on Meteorology, Climatology, or American Geography. Correspondence on events of current interest is invited, and accounts of local newspapers concerning them will be welcome. Notes on local climate will be published and the columns of the JOURNAL are freely open for worthy communications on all matters within its scope. The editors do not hold themselves responsible for any communications which may be signed or attributed to other authorship than their own. Address all communications to

AMERICAN METEOROLOGICAL JOURNAL CO.,
Ann Arbor, Mich.

THE UNIVERSITY OF MICHIGAN.

More than 80 Instructors.

A LARGE AND CHOICE LIBRARY

Freely accessible to Students.

Its various departments of Physical Science, Biological Science and Engineering are thoroughly manned, and are provided with Laboratories, Observatories, Museums, Special Libraries, and Workshops.

It was the first Collegiate Institution in America to establish a special course in Meteorology.

Greatest possible Freedom in Studies allowed.

Fees very moderate. For further information address

JAMES H. WADE, Secretary,
ANN ARBOR, MICH.

THE AMERICAN
METEOROLOGICAL JOURNAL.

VOL. III. ANN ARBOR, JANUARY, 1887. No. 9.

CURRENT NOTES.

SNOW AS A CAUSE OF COLD WEATHER.—Dr. Assmann gives in last February's number of *Das Wetter* an account of the extreme cold of January 8th, 1886, in the Thuringian basin, and its relation to the snow then lying on the ground. He concludes: 1. A thick sheet of snow, under dry atmosphere and clear sky, aids a rapid and intense cooling of the air by increasing heat radiation, by hindering the (diurnal) warming of the ground and by diminishing the warming effect of the ground on the air; 2. the deeper the snow, the greater the cooling; 3. the cold is especially intense when the snow lies in a trough-like depression enclosed on all sides by high lands. The importance of the low conducting power of loose snow, and its high reflecting power are also referred to in the paper. It has seemed to me that the expression "increase of heat radiation" (Verstärkung der Wärme-Austrahlung) may perhaps be misleading here, for the snow radiates very little heat, or in better words, emits very little radiant energy. The consideration may be limited to the processes going on at night, as the intense cold is chiefly a nocturnal affair. In the first place, the amount of radiant energy emitted by snow is small, for it is a transparent substance with good reflecting surface: it does not lose heat by radiation as well as opaque, non-reflecting substances do. It is in this respect a poorer radiator than the surface of the ground. Why, then, does the surface of snow fall to so low a temperature? It must be chiefly on account of its very low conductivity.

The radiation that goes on from its surface is small in amount, but very effective in its results. This may be seen by comparing it with a rough metallic body, from whose surface radiation is very active, but not effective in cooling it; for nearly as fast as the surface loses heat, heat flows by rapid conduction from within and almosts makes good the loss. With snow it is otherwise; even though its radiation is moderate in amount, it is extremely effective, for the loss of heat that it causes is very slowly compensated by conduction. Loose, fresh snow, with plenty of air between the flakes, is the type of a poor conductor, and it is essentially to this property that the low temperature, to which its surface falls, is due. Snow is a poorer conductor than the earth beneath it; so much poorer that its surface cools faster in spite of its weaker radiation and higher specific heat. Conduction rather than radiation therefore seems to me to be the process needing emphasis; and snow-radiation should be described as *effective* rather than strong.

This comment is rather on a matter of definition than on a question of fact, for Dr. Assmann's paper is a model of critical, discriminate use of observations. The effective way in which the snow hinders the diurnal warming of the ground is shown by comparing the change in air temperature over snowy and bare districts; on the former, the temperature hardly rises even at noon; on the latter, there is a distinct warming. This is because the snow reflects away nearly all the incident radiant energy, and the little that it absorbs is largely occupied in affording energy for evaporation: it might be added that the rays which are transmitted through the snow and absorbed by the ground, produce heat too far below the snow surface to have much or any control on the temperature of the air above. The depth of the snow is also shown to have a distinct effect in increasing the cold; for the deeper the snow, the more perfectly is terrestial heat shut in. Now that our volunteer observers are increasing to so large a body, we must look to it that their records receive as careful consideration as that which Dr. Assmann gives the reports of the *Verein für Wetterkunde in Mitteldeutschland.*

W. M. D.

ARIZONA DESERT LANDS AND THEIR IRRIGATION.—In his recent report Governor Zulick calls attention to the desert lands of the territory and their prospects, with irrigation, in words which will be a surprise to those who have not followed the history of Arizona for the last few years. He says:

Arizona contains nearly 114,000 square miles, about 72,000,000 acres of land. About 18,000,000 acres are utilized for stock-raising, and upon it graze nearly 1,000,000 head of cattle, more than 1,000,000 sheep, besides horses, mules, and other domestic animals. Nutritious grasses grow everywhere, and, could the balance of the land adapted to grazing be utilized for that purpose, this would become the greatest stock-raising country in the United States. The want of water is the only drawback to its occupation and development. For the most part these lands lie so that water reservoirs could be constructed to preserve the water from the rains of summer and the melting snows of winter for the use of the herds of cattle and other stock. Of the remaining 36,000,000 acres of land, which are mineral and agricultural, two-thirds are arable could they be irrigated; of these 1,000,000 acres can be reclaimed by a judicious appropriation and distribution of the present water supply. All farming in Arizona, except in a few of the mountain valleys, to be successful must be attended by irrigation. To show the success of horticultural and agricultural enterprises under irrigation, I need only cite the following among many facts which can be collated.

In January, 1878, a party of four, as an exploring party for a colony, located a water-right on Salt river in Maricopa county, and entered the present town-site of Mesa City, consisting of 640 acres. In February they were joined by their families and and others, thirteen families in all, and went into camp. February 18 they began active operations excavating their ditch to irrigate their land, which was completed and the water introduced upon their town-site and farm land after nine months of hard labor.

The canal is owned by a stock company consisting of 200 shares with a par value of $100 per share, which now have a cash value of $500 per share. The main canal is 10 miles long, with

a capacity sufficient to reclaim 15,000 acres of desert land. Several miles of the canal traverse the bed of an old Aztec ditch that had been cut through a layer of cement. This prehistoric water way, excavated probably thousands of years ago, was not less than 30 feet wide at the top and 20 feet at the bottom. It is estimated that a saving of $25,000 was made by following the alignment of this old canal, which to these pioneers was the important item that made their enterprise successful.

The section of land entered as a town-site was divided into 10-acre blocks and these subdivided into 1¼ acre lots for residence and business property; the land immediately surrounding the town was entered by the various members of the colony for more extensive agricultural purposes.

The first water was turned upon the land where the town of Mesa now stands in November, 1878, and not until the winter of 1879–'80 was much seeding or planting done, for they had homes to build, land to clear, and other preparatory work to do. It must be remembered that this energetic, industrious little colony of thirteen persons settled upon a desert, where for centuries the sun only smiled upon the sparse growth of cacti and sage-brush; where there was no trace of verdure, and whose only visitant was an occasional coyote in his lonely wanderings.

The transformation after six years has been complete. It is regarded as a colony no longer. Mesa has a population of 700. The original town-site is dotted over with beautiful homes built of rustic red-wood neatly painted, some of brick, and others of adobe; all surrounded by fruit trees and vines, they present a picture of Arcadian homes set in groves of fig, almond, ash, locust, pepper, willow, umbrella, and pomegranate trees. Altogether there are 7,000 acres under a high state of cultivation, devoted to the raising of cereals, alfalfa (French lucerne), with extensive orchards and vineyards supplying and enriching a population of 1,300 people. Several crops of cotton have been raised here. Grapes are made into wine and raisins, not excelled by those of California.

To the above facts I invite the attention of the Department, in order to demonstrate the importance of irrigation to the future

development of this territory, and to urge upon Congress the necessity for a liberal appropriation for a hydrographic survey with a view to obtaining water by storage reservoirs in the mountain sheds, and to test the utility of artesian wells for that purpose in the valleys.

Under present conditions, of the 72,000,000 acres of land in Arizona there is available to the stock-raiser not more than 20,000,000 of acres, and to the farmer and horticulturist not more than 1,000,000 of acres. The extended valley of desert land stretching from Yuma to the mountain ranges of Pinal and Pima counties, 200 miles in length and more than 125 miles in width, containing about 15,000,000 acres of land, could, with irrigation, be made as productive as any portion of southern California. Forty acres of this land in a vineyard, orange, nut, or olive orchard would yield a small fortune every year to the fortunate owner. That a great part, if not all, could be reclaimed by artesian wells I think admits of no reasonable doubt.

Could capitalists secure this vast domain by reclaiming it I have little doubt but a corporation would be formed to do so; but in that event, if success attended their undertaking, the land would pass under control of a syndicate of millionairs who would reap the advantages that should accrue to the honest settler and worthy homesteader.

It would be better that Congress should, by a scientific survey and practical test, demonstrate the feasibility of artesian wells for giving the needed supply of water, and if the experiment proved successful it could advance the price of these lands and limit the amount which should be entered under the homestead law to 40 acres, and by entry to 80 acres to each individual purchaser. This law should be made applicable to all vineyard and citrus-fruit lands.

Congress made an appropriation to the territory of Colorado for artesian well-boring, which demonstrated the practicability of this method of obtaining a water supply for irrigation in what is now that state.

In and around Denver a well irrigates from 40 to 50 acres; if one-half as good results could be obtained in Arizona we could

produce wine, raisins, fruits, nuts, and olives enough to support in affluence a population of 2,000,000 people.

In comparison with the magnificent results both possible and probable the outlay to test the experiment would be a mere bagatelle.

It is wise for Congress where possible to provide homes for our ever increasing population, and an outlay on its part of two or three hundred thousand dollars would demonstrate whether three or four millions in the near future could make happy homes in this territory, in addition to the large population which under natural (present) conditions we can provide for. When once the experiment is made, and is proved to be successful, private enterprise will do the rest.

Ditches and canals are being now constructed in all parts of the territory; more and more land is being cleared every year and placed under cultivation. In two years more it is quite likely that all the land which can now be irrigated will be owned and occupied.

The Imperial Meteorological Observatory at Tokio was established in June, 1875, but all necessary arrangements were completed only in January, 1876. In 1882 the care of simultaneous observations at the other stations of the Japanese service and the telegraphing of weather reports were added to the duties of the director. This post is held by Mr. I. Arai, and that the work is well and conscientiously done is shown by the frequent publications of the observatory. The first ten-year report has recently been issued and contains both numerical and graphical representations of the changes of the meteorological elements. The director also publishes at the same time a report for 1885, prepared from tri-hourly observations, which has the same features as the ten-year report.

From the observatory is also issued the annual report of the Japanese weather service. The report for 1885 quite resembles those of preceding years, to the features of which we have referred before. In this year's report are given maps of movements of areas of high pressure as well as those of low press-

ure. Their paths agree well with those of the cyclonic areas, but they have more tendency to describe loops, especially at the southern end of the islands. Their velocity is, curiously enough, on the whole, greater than the velocity of the cyclonic areas.

The wettest part of Japan is a small area on the Sea of Japan, near Kanazawa,—about the middle of the west coast of Nippon. Next to that comes the fringe of coast on the southern edge of Kiushiu and Shikoku.

The number of stations reporting is 29, including two in Korea and one in Russian Mantchouria.

U. S. Consular Reports.—The consular offices of the government are under orders to report to Washington any matters which may come under their notice that might be of interest to American commerce, and occasionally an important subject is selected in the office of the Secretary of State which all consuls are expected to investigate in their respective localities. These various reports are collected and printed, one or more issues appearing each month. This published monthly abstract is a thick pamphlet of the series of which we are now in the sixth volume. The reports are full of information to manufacturers and merchants, and also contain much matter of value to geographers and meteorologists. The system is so perfect and effective that the British foreign office is reconstructing its service on our model.

Protection from Lightning.—Experiments carried on in Dresden on nickel as a material for lightning rods, are reported as successful. The advantages are that the metal is non-corrodible and will keep bright at the points. The latter is particularly essential to the efficiency of rods as collectors of atmospheric electricity.

As an indication of the size of the circle of protection of good lightning-rods, the following facts may be of interest: They are reported by the city architect, Schiller, of Esslinger, and relate to the German village of Mottingen. On June 17th, during a thunder-storm, lightning struck a pear tree 33 feet

high. On one side, 115 feet away, was a school-house, with a rod 56 feet high. On the other side was a church, 328 feet away, and having a lightning-rod reaching up 154 feet. Both rods are well placed, and had worked well when tested, and the level of the foot of the tree is about the same as that of the two buildings. An evident conclusion is that the radius of the circle of protection is not more than twice the height of the rod.

THE LAW OF STORMS IN THE EASTERN SEAS.—Mr. W. Doberck, the government astronomer for the colony of Hong Kong, published a plain and simple account of the typhoons, with instructions for mariners, in the Hong Kong *Telegraph*, and this has now been reprinted in pamphlet form. The map of paths of the twenty principal typhoons of 1884 and 1885 shows a more marked tendency, than had been heretofore pointed out, on the part of these cyclones to continue their course northward over the Japan Sea or northeastward on the continent. Not one started fairly eastward until above 30° of latitude; of the eight or ten which traveled eastward, the most took this course above 40°.

The Philippine Islands occupy the same relation to the North Pacific typhoons that the West Indies do to the hurricanes of the North Atlantic.

TEMPERATURE AND RAINFALL IN THE CROYDON DISTRICT.—This district is immediately south of London, and includes Greenwich and Kew. It comprises an area of about 500 square miles. The report is made to the Corydon Microscopical and Natural History Club by Mr. Henry Storks Eaton, F. R. Met. Soc., and in the list of observers are several well known names. Probably no climate has been studied for a longer time or more thoroughly than that of London and its vicinity, and this is a valuable addition to the great mass of literature on the subject. The report covers the years 1881–85 inclusive.

The range of altitudes in the area covered is very moderate,—from 102 to 259 feet—yet in this range of 157 feet noticeable differences in the temperature are shown. The mean tempera-

ture of the highest is 0.56° higher and the daily range is 2.08 less than of the lowest station. This is probably due to the topography, the cold air, other things equal, being heavier and settling down to the lower grounds.

The rainfall observations extended over a greater range of elevations. It was found that the greatest rainfall occurred at elevations between 600 and 800 feet (31.66 inches). Above 800 feet, it decreased slightly (31.36 inches), and below 600 it fell regularly until below 200 feet it averaged 23.27 inches.

THE USE OF OIL, to lessen the effect of dangerous seas, still continues to give very favorable results and the accumulated evidence is of the most satisfactory nature. In one case the "slick" made by the oil extended thirty feet to windward, and the Hydrographic office concludes that the oil is of use when the vessel is reaching ahead at the speed of eight or nine knots, with a beam wind and sea.

UTILIZATION OF EARTH'S INTERNAL HEAT.—An attempt is about to be made at St. Augustine, Fla., to sink a twelve-inch artesian well to a depth sufficient to obtain water hot enough to heat buildings, pure enough for domestic purposes and with pressure enough to run heavy machinery. The facts upon which this peculiar experiment are based are, that water can be found in Florida by boring two hundred and fifty feet. The artesian wells in that State have considerable pressure, and from a depth of six hundred feet send water of warm temperature to a head of forty-five feet when piped. The question of running heavy machinery by artesian well power is by no means purely experimental—it is done in many locations in France, already, and the experience of the French shows that the deeper the well the greater the pressure and the higher the temperature. At Grenelle, France, a well sunk to the depth of 1,802 feet and flowing daily 500,000 gallons, has a pressure of sixty pounds to the square inch, just double that of the 600 foot well at Jacksonville, and the water from this Grenelle well is so hot that it is used for heating the hospitals in the vicinity.

The earth's internal heat is already forced into practical service at Pesth, where the deepest artesian well in the world is being sunk to supply hot water for public baths and other purposes. A depth of 3,120 feet had been reached at the time of our latest information, and the well supplies daily 170,000 gallons of water heated to 158 degrees Fahrenheit. The boring is to be continued until the temperature of the water is raised to 176 degrees.

DEPTHS OF FRESH-WATER LAKES.—Apropos of some claims for remarkable depth for lake Temisconata, Province of Quebec, Professor John LeConte gives in *Science*, the following interesting table:

Fresh-Water Lake.	Heighth of surface above sea.		Maximum depth.		
	Feet.	Metres.	Feet.	Metres.	
Temisconata	400	121.9	500	152.4	Bailey.
Superior	609	185.6	1,010	307.8	Lake survey
Michigan	582	177.4	864	263.3	" "
Huron	582	177.4	705	214.9	" "
Erie	573	174.6	324	98.7	" "
Ontario	247	75.3	738	224.9	" "
Tahoe	6,247	1,904.1	1,645	501.4	LeConte.
Crater	—	—	1,996	608.4	Dutton.
Leman	1,226	373.7	1,017	310 0	Forel.
Como	699	213.0	1,926	587.0	
Maggiore	686	209.0	2,612	796 0	
Baikal	1,360	414.5	12,356	3,766 0	

Lake Baikal is popularly said to have no bottom, but we observe that the latest writer on these subjects, Marinelli, gives its depth at only 1,373 m, or 4,505 feet, less than one third that given by Professor LeConte. In the three other foreign lakes his figures differ somewhat (being, in order, 334, 588 and 850 m.)

ARGENTINE METEOROLOGY.—Dr. Oscar Dœring, of Cordoba, still continues his meteorological studies. In the fourth part of the eighth volume of the *Boletin* of the Academy of Sciences of Cordoba, he has a list of fifty altitudes obtained by the barometer in the State of Cordoba and a study of the mean interdiurnal variability of the temperature of Ushuaiá, Tierra del Fuego. Ushuaiá is in latitude 54° 53′ south; only two more

southern stations have been occupied for regular observations, viz: Bahia Real of Georgia del Sur, at latitude 54° 31′ and about Cape Horn at 53° 31′ south. The observations were taken by an English missionary, Rev. Thomas Bridges, from 1876 to 1883 and are published in Dr. Gould's *Anales* of the Argentine Meteorological office. The mean monthly variation is 1.92° centigrade, being greatest in January (2.18°) and least in September (1.61°). The largest monthly value was in August 1883 (2.85°). The least in April 1876 (1.07°). The prevailing winds are north and west.

Earthquake Records of the Rocks.—In many parts of the world the process of denudation has left detached columns and pinnacles of rock which are readily overthrown and destroyed, while in countries once worn by glaciers there are thousands of poised boulders which are equally sensitive to shocks. These natural seismometers furnish a means of determining whether severe earthquakes have visited, since a very remote period, places where they have never been recorded. A study of such evidence has shown Prof. N. S. Shaler, says an exchange, that certain portions of the Rocky Mountains, the regions of the Upper Tennessee river, the coast district of Maine, with Saxony and some other parts of Europe, have been exempt from great shocks for some tens of thousands of years. The idea is an ingenious one and it would be interesting to map more exactly the regions thus shown to be without earthquakes.

Review of New England Thunder Storms of 1885.—In a paper to the American Academy on the thunderstorms under the survey of the N. E. Meteorological Society for 1885, Professor W. M. Davis, says:

In view of the many questions that remain unsettled, it does not seem safe to enter yet very far on the interesting task of generalizing the results obtained; but a brief statement may be allowed in review of the foregoing pages.

Table V. gives the hours of "loudest thunder" for June, July,

and August, 1885, and their percentages; also the totals for the three months. Owing to the growth in the number of observers through June, and the omission of a number of reports not adapted to being counted here, the table cannot be taken as giving a precise view of the relative frequency of storms in the three summer months; and, again, on account of the smaller number of observers who record the storms that occcur at inconvenient hours, the percentages of night observations are probably below their true figures. Nevertheless, the general ditribution of storm occurrence is clearly made out.

TABLE V.—Hours of "Loudest Thunder."

Hours.		June.		July.		August.		Total.	
		Obs.	Per Ct.	Obs.	Per Ct.	Obs.	Per Ct.	Obs.	Per Ct.
A. M.	0–1	1	0.18	3	0.35	3	0.51	7	0.35
	1–2	0	0.00	3	0.35	10	1.70	13	0.65
	2–3	5	0.91	3	0.35	8	1.36	16	0.80
	3–4	11	2.00	5	0.58	9	1.50	25	1.25
	4–5	27	4.90	5	0.58	10	1.70	42	2.10
	5–6	47	8.64	3	0.35	16	2.72	66	3.30
	6–7	1	0.18	4	0.47	5	0.85	10	0.50
	7–8	4	0.73	5	0.58	12	2.04	21	1.05
	8–9	8	1.45	12	1.39	27	4.50	47	2.34
	9–10	18	3.27	5	0.58	18	3.00	41	2.05
	10–11	7	1.27	11	1.28	13	2.21	31	1.55
	11–12	8	1.45	26	3.02	3	0.51	37	1.85
P. M.	12–13	16	2.90	69	8.12	16	2.72	101	5.04
	13–14	49	8.88	57	6.61	22	3.74	128	6.39
	14–15	129	23.41	68	7.89	24	4.08	221	11.04
	15–16	106	19.06	130	15.08	38	6.46	274	13.69
	16–17	38	6.90	164	19.02	79	13.43	281	14.04
	17–18	56	10.34	153	17.75	101	17.17	310	15.48
	18–19	8	1.45	78	9.05	79	13.43	165	8.24
	19–20	2	0.36	37	4.29	47	7.92	86	4.30
	20–21	3	0.54	14	1.62	33	5.61	50	2.50
	21–22	1	0.18	6	0.70	12	2.04	19	0.95
	22–23	5	0.91	0	0.00	3	0.51	8	0.40
	23–24	1	0.18	1	0.12	1	0.17	3	0.15
		551	100.10	862	100.13	589	99.88	2 002	100.01

The excess in the afternoon hours appears distinctly enough. But the time of greatest frequency does not depend on the hour of the day. If we take, on the one hand, southern Vermont, southwestern New Hampshire, western Massachusetts, and western Connecticut as a western group of areas, and, on the other hand, eastern and southeastern Massachusetts and Rhode

Island,* as an eastern group, the hour of maximum percentages come out as follows:

Area.	June.	July.	August.	Mean.
Western, - - -	13–15	15–16	16–17	15–16
Eastern, - - - -	14–16	18–19	18–20	18–19

This clearly implies that distance from some at present unknown starting-point exerts a decided influence on the hour of maximum storm frequency; or in other words, that most of our New England storms come to us ready made from a source where they begin at a rather uniform hour of the day. Another season's work may perhaps determine where our storms begin. The importance of this question in the attempt to predict thunder-storms is evident. In Bavaria Von Bezold finds a second faint maximum in the early morning hours, and attributes it to the arrival of storms from a source more distant than that which furnishes the more numerous ones of the afternoon. Our faint secondary maximum, at five to six o'clock in the morning, may have a similar meaning; but the question cannot be decided from the observations of a single season, when one or two storms would exert a strong effect on the total percentage.

A brief examination of the "general account" suffices to show that, while the summer storms there recorded are much more frequent than they are in the winter months, still, they are not at all uniformly distributed through the summer season: they appear in greater number and size for a few days, and then are almost or quite absent for a time. The cause of this seems to be found in their dependence on the larger disturbances in the atmospheric circulation, for which I should wish to use the name of "cyclonic storm" (following Piddington, Redfield, Ferrel, and many European writers), but which are perhaps more generally known by the phrase "areas of low pressure," as used in the Signal Service publications, or as "barometric minima" in Germany. It is as a rule only when we stand in a certain attitude with respect to the centre of these low pressure areas that large and well-developed thunder-storms appear. It may there-

* Fourteen Reports of the squall of July 21, falling between 12h and 13h, are omitted in this count.

fore be concluded that the development of such storms depends, not only on the heat of summer afternoons, but also on the equilibrium of the atmosphere as determined by the circulation of cyclonic winds.* The greatest number of our summer thunder-storms occur when a centre of low pressure lies to the north or northeast of us. But there are also examples of storms occurring in areas of high or equable pressure, as on August 1st; these would seem to correspond to the *Wärme-Gewitter* of Mohn, and to depend on a local warming of the lower air sufficient to bring about the unstable equilibrium that in the other cases (*Wirbel-Gewitter*) depends on the arrangement of upper and lower currents in the cyclonic circulation. A more peculiar exception to the general rule of occurrence is found on certain dates when a well-developed low pressure centre passed north of New England, without bringing any local storms to us. The most pronounced example of this condition was on July 17th, in the middle of a long period remarkably free from storms; it was one of the hottest days of the summer, and yet passed without reports worth mentioning. Other exceptions have a more visible explanation: on June 15th, low pressure centres stood both northeast and northwest of us, and no storms occurred; on July 10th, low pressure centres were north and south of us, and we had only light rains; the occurrence of two neighboring low pressure areas may in these cases have interfered with the arrangement of upper winds needed for the development of the heavy clouds of thunder-storms.

The direction of motion of thunder-storms seems to be about at right angles to the radius joining them with the low pressure centre; that is, about parallel with the higher winds in which they are borne. This is clearly shown in the following table, embracing thirty-five storms whose course was sufficiently well determined to be used in evidence.

---

*The first definite announcement of the fact that thunder-storms have a definite position in areas of low pressure was made by Marié-Davy, of the French Meteorological service in 1864: "The appearance of storms always coincides with the presence of rotary winds known under the name of 'bourrasques.'" This conclusion has been confirmed by other European services, and by Prof. H. A. Hazen in this country. Lieut. Finley has shown that it obtains also for our tornadoes.

TABLE VI.

Motion of Thunder storms.	Direction to Low Pressure Centre.			
	West of North.	North.	N. N. E.	N. E.
North of East.....	7	1	1	0
East.....	1	4	2	4
South of East.	0	2	7	6

The relation of the velocity of local storms to the gradients and the velocity of the cyclonic areas in which they occur, needs still further investigation. The same may be said of the conditions that determine the arrival of some storms early in the day, and of other storms late; the passage of some storms with apparently undiminished strength off the sea-coast and their endurance into the evening, while others act in the opposite way; and the maintenance of high temperatures after some storms (morning squall of July 21, and morning storm of August 4), while most are followed by decidedly cooler weather.

The surface winds flowing towards the storm at a little distance from it, and the squall commonly met blowing outwards in front of the rain area, are well defined on many occasions. The relation of the rain to the out-blowing squall is variable; in many cases the former seems to be the effect of the latter; but in others we have heavy rain and no squall; sometimes the squall is felt at only a few stations, while the heavy rain is general. Many observers speak of a connection between lightning flashes and an increase in the rain-fall immediately following; it is quite possible that this relation exists, but the evidence usually quoted to prove it does not seem conclusive.

The more general distribution of storms in the area of low pressure, their total duration, and the possibility of their surviving the cooler hours of night, are problems that can be better determined by the work of the Signal Service in reviewing the more detailed studies of local services. It is hoped that many of these problems may find their solution in that larger fund of material towards which this report is offered as a contribution.

ROYAL METEOROLOGICAL SOCIETY.—The usual monthly meeting of this society was held on Wednesday evening, the 15th

instant, at the Institution of Civil Engineers, Mr. W. Ellis, F. R. A. S., President, in the chair.

Mr. G. R. Farncomb, B. A., Mr. C. E. B. Hewitt, B. A., and Capt. S. Trott, were balloted for and duly elected Fellows of the society.

The following papers were read:

1. "On the Proceedings of the International Congress of Hydrology and Climatology at Bearritz," by Mr. G. J. Symons, F. R. S. This Congress was held in October, and was divided into three sections, viz.: Scientific Hydrology; Medical Hydrology; and Climatology, scientific and medical. The total number of papers read was 109. An exhibition was also held in connection with the Congress. The excursions were of primary importance to the medical men, and extended over a period of three weeks. The places visited were: Bayonne, Cambo, Dax, Arcachon, Pau, Eaux-Bonnes, Eaux-Chandes, Cauterets, Lourdes, Bagnères de Begorre, Luchon, Ussat, Ax, Montpellier, Cette, Boulou, Amèlie les Barns, La Preste, Banyulo sur mer, and Thues.

2. "Report on the Phenological Observations for 1886," by the Rev. T. A. Preston, M. A., F. R. Meteorological Society. The weather was on the whole very ungenial, and everything much retarded; it was also very fatal to insect life, so that the complaints on this head have been far less than usual. Bush fruits were *very* abundant; strawberries and peas were spoilt by drought in many places; stone fruits, except plums, were not abundant; plums were extraordinarily plentiful, so much so that they realized nothing in the markets, the cost of picking and carrying often being more than they realized. Apples were very poor from the destruction of the bloom by heavy rain. Hay was good and plentiful, and well harvested; corn and other grain were not up to an average; root crops, were, as a rule, remarkably good.

3. "A Criticism of certain points of Prof. Langley's Researches on Solar Heat," by Prof. S. A. Hill, B. Sc., F. R. Meteorological Society. These experiments were carried out at Mount Whitney, in southern California, during 1881.

4. "Account of the Hurricane of March 3rd-4th, 1886, over the Fiji Islands," by Mr. R. L. Holmes, F. R. Meteorological Society. This storm was the most destructive that has ever been known to occur in the Fiji group. The lowest barometer reading was 27.54 inches at Vuna, in Taviuni. The storm was accompanied by a great wave from eighteen to thirty feet in height, which swept over the land and caused an immense amount of damage. It was reported that 50 vessels were wrecked and 64 lives lost during this hurricane.

5. "Results of Meteorological Observations made at the Military Cemetery, Scutari, Constantinople, 1866-'85," by Mr. W. H. Lyne. The annual mean temperature is 58.4°, the highest temperature registered was 103.6° on June 22nd, and the lowest 13.0° on January 25th, both in 1869. The annual rainfall is 29.29 inches; the greatest fall in one day was 4.06 inches on September 25th, 1866.

FORESTS AND FLOODS IN SOUTHERN CALIFORNIA.—It seems, from a letter by Mr. Abbott Kinney published in the Los Angeles *Weekly Tribune*, that the old story is repeating itself early in southern California. He says:

The floods in southern California are becoming each year more violent and destructive than they were formerly, on equal rainfalls. The testimony on this point is uniform, complete, and unimpeachable. It comes from well-known and representative men; in fact, all old residents who have been observers confirm this fact.

The streams now nearly all bring down more sand, gravel, and boulders, rise more rapidly, cut away more land, and dry up more quickly than formerly. Judge Eagan informs me that during his eighteen years' experience at San Juan the streams have quite changed their character. The average perennial flow, he thinks, has diminished fully fifty per cent. Where the padres had the head of their ditch to take out water to irrigate the mission lands is now dry sand all summer. On the other hand, after rains these streams rise suddenly and violently, and come down full of mud and erosive power, and cut away or cover up

the valuable valley lands. The judge lost ten acres in this way in the last floods. Mr. Grimes says the same thing of the Ventura streams, and cites the case of a neighbor who had 200 acres swept away by the Santa Clara. Mr. John E. Jackson, so long our county surveyor, and now the land valuer of the Southern Pacific Railroad, has had, perhaps, through his business, better opportunities to observe these changes than any man living, says that the streams and washes in this southern country have, with hardly a single exception, altered for the worse within his experience. Some have cut in so deeply as to drain the soil rapidly, while cutting away and carrying off the soil, while others have spread out and deposited great fan-shaped mounds of sand and boulders. At the same time the perennial flow of the waters has diminished. Mr. Arturo Bandini, a member of one of the old Spanish families, confirms these experiences by his own, and especially cite the disappearance of a spring on the Coyote grant following the cutting of a wood above it. The fact is known to all old residents that there is not a ranch in Southern California that will carry the same, nor any thing like the same number of cattle or sheep that it formerly did. Coincident with these changes have come others. The brush and forests in the foothills and mountains have been grubbed up, cut and destroyed in one way and another. The principal agent in sweeping away the natural verdure and protection of the mountains has been fire. Fires accidentally and fires maliciously set, fires made by stock men, bee men, and fools are every year spreading the causes that must eventually make Southern California a desert. In none of the countries where desolation has followed forest destruction, such as Spain, North Africa, Greece, Palestine, Persia, etc., once gardens of the world, in none of these are the natural conditions so favorable for a quick vengeance by nature on man for any violation of her laws. You cannot violate a law of nature without paying the penalty. The penalty of destroying a forest is increased wind, increased extremes of temperature, increased flood, diminished fuel supply, and diminished wells, springs and streams.

The farmers and agriculturists are the principal sufferers.

The stock men and bee men, thinking to improve their ranges by setting fires, have by their ignorance in many cases ruined them. There are hundreds of stock ranges and bee ranges in this country that were valuable, but that are now absolutely worthless through acts of the owners done blindly against their own interest and to the injury of their neighbors and their country.

The railroads, too, have suffered severely by the floods and torrents created by forest destruction. When the trees or brush are removed there is nothing to hold the water back, nothing to allow it to percolate into the soil and rocks which supply the springs. The rains therefore rush suddenly off as from a roof, carrying the soil first, and then the gravel and boulders with them. The springs, deprived of their supply, diminish.

In the Soledad, on the Colorado, and at the Tejunga, the Southern Pacific railroad has lost millions of dollars. In the Soledad canyon alone over a million dollars have been spent on flood repairs. This great loss was caused almost altogether by fires deliberately and repeatedly set by a stock man having about eighty animals in the mountains at the head waters of the stream. The Southern California has also lost heavily in the Temecula canyon, travel at one time having been interrupted nearly one year.

AN INVESTIGATION OF CYCLONIC PHENOMENA IN NEW ENGLAND.

(Concluded.)

III.—CYCLONES WITH A SECONDARY DEVELOPMENT, OR INSTANCES IN WHICH TWO CYCLONES UNITE NEAR NEW ENGLAND.

In this group are included six cyclones of a more complicated character than those previously discussed. The formation of a second depression during the passage of a cyclone is not an unusual occurrence. It may happen in the case of any well-developed cyclone; indeed it is proper to regard a cyclone as a continual succession of depressions which are formed and dissipated in turn, rather than a definite organism moving along in a restricted path. It is probable that in a large area around the

central depression minor depressions are frequently formed, which are after a time absorbed in the main depression. Or, one of the secondary depressions may attain a development exceeding that of the primary cyclone, and absorb the latter, continuing in a path which deviates to a greater or less degree from that previously pursued. These changes cannot often be observed, because observing stations in the path of the cyclone are not sufficiently numerous, and because stations where continuous records are kept are still more infrequent. But occasionally the phenomenon occurs on so large a scale that it is well defined. The auxiliary depression may be formed several hundred miles from its primary, and pursue for a time a wholly independent path. Either may absorb the other, gaining in energy and with greater or less deflection in its path.

Another interesting phenomenon is the union of two cyclones which had a wholly independent origin. It is not always possible to tell whether two cyclones which unite are wholly independent in their origin, or are examples of a primary cyclone with a secondary development. For this reason these two cases are considered together in this discussion. There are but six instances in all, and they have been considered solely with regard to the peculiarities in the precipitation reports. They will be first described in detail, continuing the numbering from the preceding sections. The following table contains the current number, with the date of passage of each storm. The date given is that for the cyclone, whether primary or secondary, which came from the south.

TABLE XI.

Date of Passage of Combined Cyclones.

Current Number.	Date.
36	February... 10, 1885.
37	April..... 27, 1885.
38	July..... 14, 1885.
39	September.. 23, 1885.
40	February.... 12, 1886.
41	March..... 22, 1886.

It was found inexpedient to attempt to tabulate the general characteristics of these storms in the manner of Table I and V,

because each is a double storm. Two cyclones are in each case to be described, whose union occurs near New England, generally after the passage of one or both over or near the district. The data concerning the times of beginning and ending of the precipitation are quite meagre and also conflicting, on account of the dual nature of the storms. The detailed description of each storm therefore embodies the results which in the former division have been given in tabulated form.

(36) Feb. 10, 1885.—This cyclone moved from southern Texas to the Lakes as a severe storm increasing in violence. The pressure had fallen to 29.1 inches when the centre reached the Lakes. At this time a second depression appeared on the Connecticut coast, which probably formed near Long Island at a distance of about 450 miles from the path of the former. It moved northeasterly over New England with an hourly velocity of about 35 miles, and with its pressure at the centre diminishing from 29.1 to 28.9 inches. It is not known that the first depression continued its original path, though it may have done so, as there are no reports accessible so far north; it is probable that it was absorbed by the latter, which continued its journey into the Gulf of St. Lawrence. The precipitation was rain with some snow, and was heaviest in southwestern Connecticut. An amount exceeding two inches fell in an elongated region covering parts of Connecticut and Massachusetts and nearly coincident with the path of the second cyclone. The times of beginning and ending of the precipitation were not well marked; its duration in eastern Massachusetts was about seventeen hours.

(37) April 27, 1885.—This cyclone developed in Arkansas and moved to the Lakes, where it was reinforced by a depression from the northwest, the pressure at the centre falling to 29.6 inches. At this time a second depression appeared on the Virginia coast, which probably developed in that vicinity at a distance of about 500 miles from the path of the former. It moved into the Atlantic and passed by New England in a northeasterly direction about 150 miles from the coast with an hourly velocity of 47 miles. The primary depression advanced down the St. Lawrence valley as far as Montreal, and then ceased to maintain an

independent existence. As neither path was very near New England the precipitation was not excessive; the maximum area, slightly exceeding one inch, was in southern Rhode Island, or in that part of the district which lies nearest to the path of the second cyclone. The duration of the rain in eastern Massachusetts was about 13 hours. The time of beginning of the rain was well marked, showing a northeasterly progression with an hourly movement of about 20 miles.

(38) July 14, 1885.—The primary cyclone came from the west reaching the Lakes with a central pressure of 29.6 inches. A subsidiary depression formed, which became well marked over Chesapeake Bay with a central pressure of 29.7 inches, about 400 miles from the former. The latter probably moved rapidly across New England in a northerly direction uniting with the former, though its exact path cannot be traced. The rainfall was not heavy, but amounts exceeding one inch were reported in western Connecticut and Vermont and the Hudson valley corresponding with the supposed path of the auxiliary depression. The rainfall front and rear moved in a northeasterly direction, but the data are not sufficient to determine the rate of movement. An interesting feature of this storm is the absence of thunder and lightning in connection with its passage.

(39) Sept. 23, 1885.—This is an excellent instance of the union of two cyclones, each well developed, the one from the west belonging to the class discussed under the first division of this paper, the other from the southwest belonging to those of the second division. The former moved eastward north of the Lakes and the centre was about 200 miles north of Lake Ontario on the morning of Sept. 22d, with a central pressure of 29.4 inches. The latter came from the Gulf of Mexico; it had moved so slowly as it entered the country that disastrous rains had occurred for a succession of days. (At Galveston the unprecedented amount of 16.53 inches fell in six successive days.) On the morning of the 22d, the centre was off the North Carolina coast, with pressure 29.5 inches. The pressure diminished rapidly as the cyclone moved northeasterly about 75 miles from the coast. The former cyclone turned to the southeast near

Quebec, its pressure remaining very nearly constant, and on the morning of the 23d the two centres united near Eastport, Maine, the combined storm having a central depression of 28.8 inches. After the union the storm continued in a northeasterly direction. In this instance the cyclone from the south was the more intense of the two as they neared New England, and seems not to have altered its path under the influence of the other but to have drawn the latter completely into its own control. The rainfall in this double storm was light in central New England, but the amounts were larger near the storm paths. Maximum areas exceeding two inches occurred at Nantucket, over which the second cyclone passed, and along the Maine coast where the depressions united; and an area exceeding one inch was located in northern Vermont nearest the path of the former cyclone. The times of beginning show a northerly progression about five hours in advance of the southern cyclone, and the times of ending a similar progression about five hours after its passage. There was also a later rain on the 23d in the northern states, after the cyclones had united. The rainfall was evidently due in the main to the southern cyclone.

(40) Feb. 12, 1886.—This was an extraordinary storm, both from the number of its secondary depressions and the consequent irregularity of its path, and also from the excessive rainfall which attended its passage near New England. As detailed in the *Monthly Weather Review*, it formed in the northwest and moved southeasterly to the Gulf of Mexico with the formation of several auxiliary depressions, making its central path difficult to determine. It then moved northerly to the Lakes on Feb. 11th and 12th, with a central pressure 29.7 inches. A second development followed one day later along the eastern coast, with a central pressure also 29.7 inches. Moving more rapidly and curving to the northwest across Pennsylvania and western New York, it united with the other at Lake Ontario on the 13th. The combined storm with increasing energy moved down the St. Lawrence valley to the Gulf of St. Lawrence, beyond which it has not been traced, and was probably dissipated.

The rainfall in this storm has never been surpassed in any storm on record in Rhode Island, where the maximum area was

located, and disastrous floods resulted in consequence. Its distribution was made the subject of special study, the results of which were published in *Science* No. 163 and reprinted as a supplement to the *Bulletin* of the N. E. Meteorological Society for February, 1886. From this article the following extracts are reproduced:

"The region covered by the greatest rainfall includes the states of Connecticut, Rhode Island and the eastern portion of Massachusetts. * * * * The special reports collected by the New England Meteorological Society, from one hundred and thirty-two observers, show that in a region covering more than one-half of Rhode Island, and the southeastern part of Connecticut, over *eight* inches of rain fell. The amount diminishes rapidly west and east of this region, about two and one-half inches having fallen on Cape Cod, and less than one inch in the northwestern part of Massachusetts. The region of heaviest rainfall is situated about four hundred miles northeast of the position of the centre of barometric depression [the second centre mentioned above,] on the afternoon of the 12th inst."

"The form of precipitation was almost wholly rain, a little snow or hail having occurred at its beginning at a few places only. The rainfall was nearly continuous for about two and one-half days, but was not of equal severity. Indeed, the greater part of the fall occurred in twenty-four hours, as is indicated by the following table, which contains the times of beginning and ending of the rain, the total amount, and the amount during a specified interval of twenty-four hours. Similar records could be given from many other stations."

TABLE XII.

Times of beginning and ending of rain and interval of heaviest rainfall at selected stations, February 10-14, 1886.

Stations.	Time of Beginning.	Time of Ending.	Total Rainfall.	Interval of 24 Hours During Heaviest Rainfall.	Rainfall in 24 Hrs.
New York.....	10th, 10.30 A. M.	13th, Noon.	3.41	11th, 11.00 A. M.—12th, 11.00 A. M.	2.99
New London.	11th, 6.00 A. M.	13th, 4.20 P. M.	8 93	11th, 11.00 P. M.—12th, 11.00 P. M.	6 66
Providence ...	11th, 1.00 A. M.	13th, 11.30 P. M.	8.13	12th, 7.00 A. M.—13th, 7.00 A. M.	5.65
Boston.....	11th, 7.45 A. M.	13th, 2.45 P. M.	5.62	11th, 11.00 P. M.—12th, 11.00 P. M	4 45
Newburyport	10th, 5.30 P. M.	13th, 10.30 P. M.	4.78	11th, 9.00 P. M.—12th, 9.00 P. M.	3.30

It will be noted that the heaviest rains occurred at the time that the secondary centre was developing in the southern states,

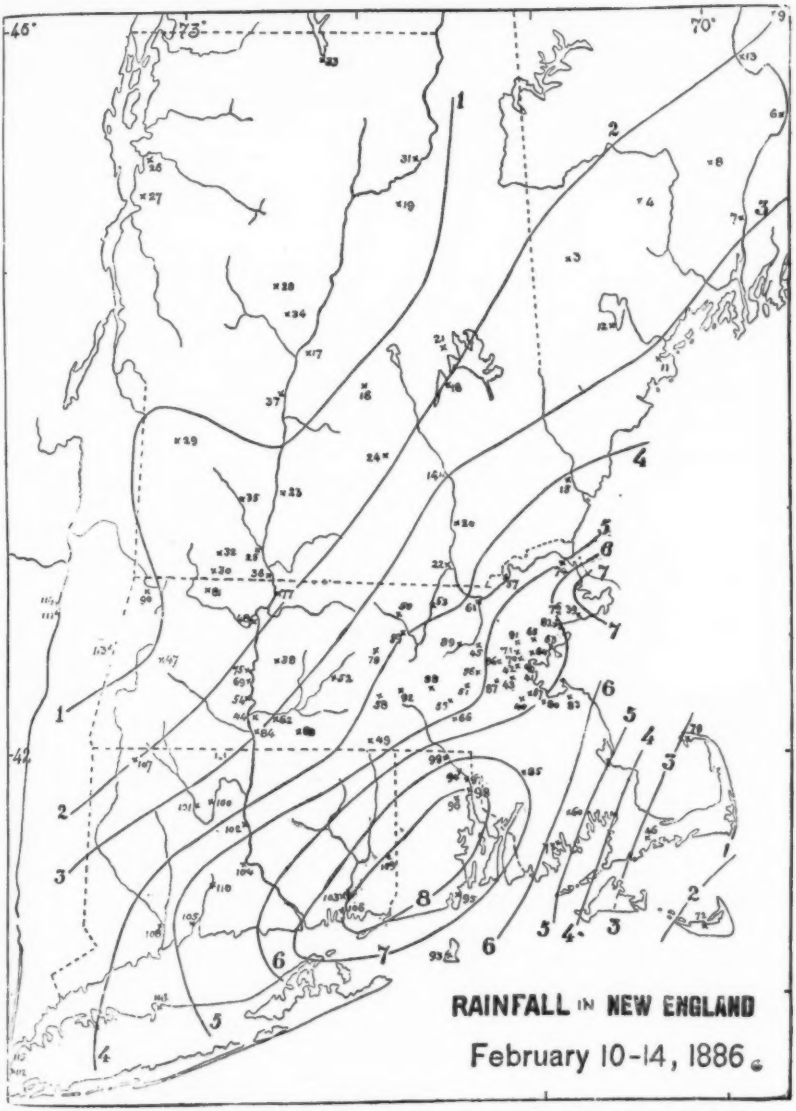


CHART X. *Distribution of Rainfall in New England, February 10-12, 1886.*
The small numbers indicate the position of the observing stations. The lines of equal rainfall are drawn at intervals of one inch.

but that the region of greatest fall was far removed from the path of either centre. The pressure had been very high before the approach of these centres. On the morning of the 11th, "at Anticosti Island the barometer (reduced to sea-level) indicated 31.01 inches; in New England the pressure ranged from 30.9 inches on the eastern border to 30.6 on the western, while a trough of relatively low pressure, 30.0 inches, extended from the Gulf of Mexico to the Lake region. Light rains were falling along the eastern part of this trough in the central states, heavy rains upon the middle Atlantic coast, and the storm was just beginning in New England." As the storm-centre developed, the pressure fell rapidly; "between 7.00 A. M. of the 12th and 7.00 A. M. of the 13th, the fall was 0.54 inches at New York, 0.57 at New London, and 0.60 at Boston."

The accompanying map shows the distribution of the rainfall; the lines of equal rainfall are drawn at intervals of one inch; they are drawn freely, but represent fairly well the individual records. The small numbers on the maps are the numbers of the observing stations in the table containing the values of the rainfall, (which is not here reproduced.)

(41) March 22, 1886. This storm has been traced completely across the country from the Pacific coast eastward. It reached the Lakes on March 21st, as an elongated depression in which were two centres apparently well defined with pressure 29.1 inches. At the same time an auxiliary depression with pressure 29.3 inches formed in Delaware. The latter moved northeasterly close to the New England coast, while the former moved rapidly easterly, the two uniting on the Maine coast on the 22d, and proceeding northeasterly into the Atlantic. The precipitation was heavy, rain and snow mixed. Maximum areas exceeding two inches were in southeastern Massachusetts where the second cyclone passed, in southwestern Maine, a few miles south of the path of the first cyclone, and among the hills in southwestern Vermont and northwestern Massachusetts.

It will be seen from the foregoing description, that each of these storms is of especial interest and would merit close study. The examination of the precipitation records and the storm

tracks, to which the present investigation is limited, seems to warrant the following conclusions, which are numbered in continuation of those of preceding divisions:

(13) In all cases where a secondary development was formed, it occurred on the *right* of the path of the primary cyclone; that is, on the south if the latter was moving easterly, (Nos. 37, 38, 41) and on the east if it was moving northerly or northeasterly. (Nos. 36, 40.)

(14) The precipitation was mainly due to the cyclone which approached from the south; that is the secondary cyclone in the above cases, and the cyclone which came from the Gulf of Mexico in No. 39.

(15) The maximum areas lie near the paths of the two cyclones, especially the southern. This accords with conclusion 10, given above in discussing the southern cyclones. A notable exception is No. 40, in which the maximum area was 300 miles east of the path of the secondary cyclone.*

(16) The precipitation was heavy in the region near which a cyclone was formed. This fact probably applies to other cyclones than those which are formed as auxiliary developments of those previously existing. It has already been mentioned in describing No. 29, as possibly indicating that the cyclone was formed near the coast.

(17) The precipitation was also especially heavy in that region in which the union of the two centres occurred.

General Conclusion.—In the preceding discussion, care has been taken to avoid theoretical considerations and to confine the attention strictly to the results of observation. The conclusions drawn have therefore been wholly empirical, depending solely upon the particular storms examined, and liable to modification if other storms should be similarly discussed. The results obtained in each division have been collected at its close in a few distinct paragraphs, which might be taken as the final conclusion or the discussion without further comment. It may be well,

* It has been conjectured that a secondary development formed on the southern coast of New England and moved northeasterly, but there is no evidence of this from the barometric records examined.

however, by way of review, to present the most important of these results in a different form, thus summing up the whole investigation.

1. The distribution of the precipitation in the several storms is very irregular over New England, and each storm seems to be well-nigh individual in this respect. There are however, indications of certain common features in the storms discussed, which may be general features of all similar storms:

(1) The maximum area of precipitation in the northern group of cyclones which entered New England from the west, lies *south* of their path at an average distance of about 100 miles; in the corresponding southern group, it lies *north* of their path at an average distance of about 150 miles. (Table II, Concl. 2, 3.)

(2) The maximum area of precipitation in those cyclones which moved north of New England, lies about 300 miles south of their path, in central Massachusetts. This may be a secondary maximum of this group of cyclones. (Table II, Concl. 4.)

(3) The maximum area of precipitation in those cyclones which entered New England from the south, lies approximately along their path. (Table VI, Concl. 10.)

(4) Maximum areas of precipitation in cyclones which have a secondary development, or in combined cyclones, are found near the origin of the secondary development, along the path of each of the component cyclones and near the place of union. (Concl. 15, 16, 17.)

(5) The conclusions given under (1) above, possibly indicate a topographical peculiarity, on account of which cyclones which enter New England from the west, deposit a greater amount of rain or snow in southern Vermont and New Hampshire and southwestern Maine. (Concl. 6.)

2. The amount of precipitation is greater in storms which enter New England from the south than from the west, in the proportion four to three. In double cyclones, it is greater in that component which comes from the south, which in cyclones having a secondary development is, in the cases examined, the secondary cyclone. (Concl. 9, 13, 14.)

3. The greater amount of precipitation precedes the passage

of the cyclonic centres. The comparison of the distance of the centre when the precipitation began with its distance when the precipitation ceased, gives for the relative duration of the precipitation before and after the passage of the centre, the approximate proportion three to two for cyclones entering New England from the west, and two to one for those from the south. The ranges are however very large. (Tables II, VI.)

4. The direction in which the rain front and rear advance is not always the same as that of the centre of the cyclone. The deviation is more marked in those which enter New England from the west than in those from the south, especially in the summer when the rain is in connection with thunder-showers. The rate of movement is also markedly different. In the western group the rate is sometimes greater, sometimes less than that of the cyclone; in the southern group it is uniformly less. (Concl. 7, 8, 11, 12.)

WINSLOW UPTON.

PROVIDENCE, R. I., Oct. 6, 1886.

LOOMIS' CONTRIBUTIONS TO METEOROLOGY.

AREAS OF HIGH PRESSURE (ANTI-CYCLONES.)

Besides storms, there are found to exist well-defined areas where the pressure of the atmosphere is above the normal and decreases from a central area outward. These are characterized by winds blowing outward near the earth's surface from the center of maximum pressure; and are usually accompanied by clear skies and a cool, dry atmosphere.

They are thus in almost every respect the reverse of storms, or cyclones, and have in consequence been called by Galton, anti-cyclones (not ante-cyclones—preceding a cyclone—as one with whom I was recently conversing thought.)

Circulation of the Wind.

From the U. S. Signal Service weather maps for 1872 and 1873, Loomis "selected all those cases in which an area of maximum pressure, or high barometer, was so situated that the direction and velocity of the wind were given at a considerable number of stations for at least half of the area. * * * * The

total number of cases derived from the weather maps of two years (1872–73) was 188." He divided the areas into quadrants, viz: north, east, south and west, by running two lines at right angles through the center of maximum pressure. "All the observations made near the point of maximum pressure were rejected; generally all of the stations included were within the first isobar, also no observations were employed beyond the isobar 30.00, and generally none beyond the isobar 30.10." Within these limits, from the observations at all of the stations Loomis determined the average velocity and direction of the wind for each quadrant separately. "The following table shows the resulting velocities and directions, and I have added a line showing the angle which the wind's direction makes with a radius drawn from the point of greatest pressure.

For High Barometer.

	West quadrant.	South quadrant.	East quadrant.	North quadrant.
Velocity of wind	5.22 miles	6.02 miles	6.48 miles	6.13 miles
Direction of wind	S. 63° 0' E	N 29° 55' E	N 36° 59' W	S 59° 15' W
Angle with radius	27° 0'	29° 55'	53° 1'	59° 15'

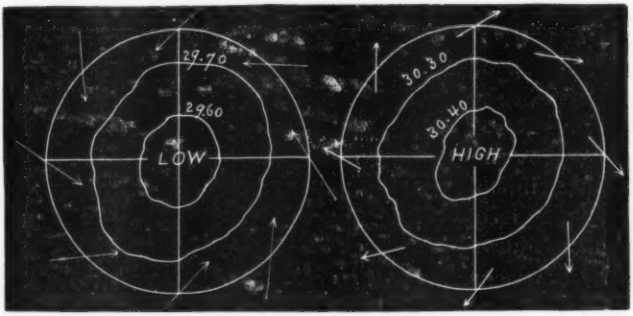
The importance of these results will be more apparent if we contrast them with the results obtained for areas of low barometer. * * * These results are as follows:

For Low Barometer.

	West quadrant.	South quadrant.	East quadrant.	North quadrant.
Velocity of wind	10.1	8.8	8.3	7.6
Direction of wind	N 58° 45' W	S 40° 25' W	S 32° 6' W	N 42° 33' E
Angle with radius	31° 12'	40° 24'	57° 54'	42° 33'

In order to exhibit these results palpably to the eye, I have constructed the two following figures, in which the arrrow at the four cardinal points show the average direction of the wind, according to the preceding tables, and the four intermediate arrows show the direction at the corresponding points as interpolated from the first four numbers. The lengths of the arrows are proportioned to the velocity of the different winds. * * * For high barometer, the average angle which the winds make with radii drawn from the point of greatest pressure is 42° 18′; for low barometer, the average angle which the winds makes

with the radii drawn from the point of the least pressure is 43° 1′. In each case therefore, the wind's direction is almost exactly



midway between a tangential and a radial movement, but approaching somewhat nearer to the latter."—Loomis' 2d paper.

Shape of the Isobars.

From the charts obtained during three years of observation in the United States and two years in Europe, Loomis found that the largest complete isobar about decided areas of maximum and minimum pressure was almost invariably oval; and average results showed that the longest axis was nearly twice the length of the shortest axis. The following table prepared by Loomis gives a summary of the results:

	LOW BAROMETER.		HIGH BAROMETER.	
	United States.	Europe.	United States.	Europe.
Av. ratio of the two axis..	1 94	1.60	1.91	1.82
Prev. direc'n of major "	N 39° E	N 31° E	N 44° E	N 76° E

In the United States, in six per cent of the cases of maximum pressure the major axis was found to be three times the minor axis; while in one per cent of the cases the major axis was four times the minor axis. Within low pressure areas "in nearly four per cent of the cases, the major axis was nearly four times the minor axis."—Looms' 5th paper.

Distribution in Latitude and Longitude of very high Pressure.

Loomis selected and tabulated all of those cases from October, 1872–74 in which the barometer at any station in the Uni-

ted States was above 30.65 inches at any station. From this table "we see that cases of high barometer occur most frequently at the northern stations. About two-thirds of the whole number were north of latitude 44°, and only 15 per cent of the whole number were south of latitude 40°. Only one of the cases occurred beyond the Rocky Mountains; and on the east side of the mountains high barometer is most frequent near the meridian 97°. After making allowance for the unequal period of observation at the different stations we find that in the neighborhood of Dakota, cases of very high pressure are nearly twice as frequent as they are at a corresponding latitude near the Atlantic coast. This fact appears still more palpable if we make the comparisons for pressures as high as 30.9 inches. In the region between longitude 86° and 102° the barometer rose as high as 30.9 inches in fifteen cases, while only one such case occurred in the district east of longitude 86°, and none occurred in the district west of longitude 102°."—Loomis' 9th paper.

Annual Period of very high Pressures.

During the time from October 1872 to October 1874 Loomis found on the U. S. weather maps "thirty-two different areas of high barometer [above 30.65], and thirty of these occurred during the six months from October to March, and none occurred during the four months from May to August. More than half of the whole number occurred during the months of December and January. Areas of unusually high pressure are thus found to occur at the same season of the year as areas of unusually low pressure."—Loomis' 9th Paper.

Place of Origin.

From the signal service observations 1872–1874, Loomis found in all of those cases of decided high pressure, viz.: those in which the barometer at any station rose above 30.65, that, "with a single exception, these areas of high barometer appeared to come from British America. About half of them appeared to originate on the west side of the chain of the Rocky Mountains, and half on the East side; but on account of the small number of stations of observation, it is impossible to trace these areas

of high pressure satisfactorily to their origin. Each area of high pressure appears to have commenced with a moderate elevation above 30.00 inches; this elevation gradually increased as the wave advanced and generally attained its maximum over Dakota and Minnesota."—Loomis' 9th paper.

Low Temperature Accompanying.

"The low temperature generally attending these high pressures is very remarkable. The lowest temperature observed in any case was 36° F, at LaCrosse. In seven cases the thermometer fell as low as 30°, and five of these cases occurred at Breckinridge. In more than half of the whole number of cases the therm ometer fell as low as zero of Fahrenheit."—Loomis' 9th Paper.

Direction and Velocity of Motion of Anti-Cyclones in the United States.

There have been three charts published by the U. S. Signal Service, which give the tracks of areas of high barometer for a month each, viz: August, 1873, December, 1884 and January, 1875. "The following are the average courses and velocities of the areas of high barometer for these months:

MONTHS.	Course.	Velocity. miles per hour.	HIGH MINUS LOW.	
			Course.	Velocity.
January	E 2° N	21.0	7° S	—5.7
August	E 41° S	18.9	46° S	+0.8
December	E 18° S	28.5	25° S	—0.5
Mean	E 12° S	14.8	21° S	—1.2

The lower line shows the averages for the three months, regard being had to the number of cases in each month. * * These observations indicate that while the average track of storms east of the Rocky Mountains, across the United States is nine degrees to the north of east, areas of high barometer advance toward a point several degrees south of east, and with a velocity somewhat less than the former."—Loomis' 4th Paper.

Causes Producing Anti-Cyclones.

"In order to discover the circumstances under which areas of high barometer originate, and the relation which they bear

to areas of low barometer," Loomis "selected from the published observations of the Signal Service [1872–74] all of those cases in which the barometer at any station rose above 30.65 inches." "In nearly all of these cases an area of low pressure immediately preceded the area of high pressure, * * * generally at a distance of 1,200 miles; and nearly all of these areas of high pressure were immediately followed by areas of low pressure on the west side, and at an average distance of about 1,200 miles. Sometimes the area of high pressure is broad enough to cover the entire continent from ocean to ocean. * * * but generally when a center of high pressure is near the middle of the continent an area of low pressure is found to be passing off on the east side, and another area of low pressure coming in upon the west side."

"One of the most remarkable circumstances attending these areas of high pressure is the force of the northerly winds which precede their formation." He gives a long table of high winds which were found to precede areas of high pressure and says: "We see that these maximum velocities range from thirty to fifty-seven miles, the average being thirty-nine miles per hour. About two-thirds of all of these violent winds were from the northwest, and all but six were from some northern quarter. * * * By the earth's rotation this northerly wind is deflected to the right. * * * The westward deflection of this current of air produces a mechanical condensation of the air on the western side of the low area. Thus areas of unusually high barometer are in part the *effect* of the violent north winds which immediately precede them."

"The fact that the lowest temperature is also the region of highest pressure cannot be regarded as accidental. The low temperature of the air increases its density, and thus contributes to increase its pressure."

"These considerations do not explain * * * cases which frequently occur in the Southern States; nor do they explain the long continuance which frequently characterize these areas of high pressure. * * * The supply of air requisite to maintain these areas of high pressure appears to come from the

air which ascends from areas of low barometer; and since in the middle latitude of North America the upper current is generally found moving from the northwest, the supply of air which maintains an area of high barometer, must come chiefly from an area of low barometer situated on its west or northwest side. This conclusion is confirmed by the observations on the direction of the upper clouds made by the observers of the United States Signal Service, at the dates of the low barometer recorded in my eighth paper. In each of these cases, when there was a well defined area of high pressure on the east side of the area of low pressure within the limits of the United States, I selected all of the cases in which the direction of the upper clouds was recorded at stations intermediate between the centre of low and high pressure. * * * The upper clouds were in all cases moving away from the low centre and toward an area of high pressure on the east and southeast side. The movement of the upper clouds was sometimes directed almost exactly towards the centre of high pressure. * * * Generally, however, the direction of the upper clouds was such as to carry them to the left of the high centre. * * * We perceive that the movement toward the left of the high centre is more than twice as frequent as towards the right; that is, while the movement of the upper clouds is from an area of low pressure, toward an area of high pressure, there is a tendency to circulate around the high centre in the same direction in which the surface winds circulate around an area of high pressure. Thus we see that near the earth's surface there is a steady but circuitous movement of the air from an area of high barometer towards an area of low barometer where the air ascends; and thence by a retrograde movement, it returns to some area of high barometer (perhaps the same one from which it started), where it descends to the surface of the earth, and again repeats the same or a similar movement."—Loomis 9th Paper.

Remarks by the present Writer.

According to the theory of Ferrel, the same forces arising from the deflective effect of the earth's rotation which tend to carry the air away from, and decrease the pressure at the centre

of a storm tend at the same time to pile up the air and increase the pressure in a ring around a storm centre, which ring has been named by Professor Davis a pericyclone. Professor Ferrel claims that the overlapping of the rings of two adjacent storms produces an area of maximum pressure, and an anticyclone. Anti-cyclones have, however, a well-marked individuality, and are usually treated by meteorologists as distinct phenomena. The inflow of the upper air into anti-cyclones has been well sustained by the work of Ley, Hildebrandson and Vettin, whose observation on the highest clouds show that, while there is a constant tendency of these clouds to move from the west, the resultant of all the directions of motion observed all around areas of maximum pressure show a convergence toward the point of maximum pressure; while the resultant motion of all the upper clouds around a storm is from the storm-centre.

Anti-cyclones are the reverse of storms and the laws which have been given in the case of storms, no doubt apply in a reverse sense to anti-cyclones, thus: *Anti-cyclones originate and are maintained by such causes as tend to make the pressure of the atmosphere over any area greater than over surrounding areas.*

This law is tacitly assumed by most writers since it is included in the definition of anti-cyclones but when we attempt to push the explanation farther we find several causes which may produce an increased pressure: 1st, a lower temperature; 2d, a lower absolute humidity; 3d, precipitation, which tends to decrease the pressure within the area of precipitation but to increase the pressure around it; 4th, the centrifugal force tending to carry the air away from the centre of storms tends at the same time to increase the pressure surrounding them; 5th, when storms approach within a given distance of one another the causes tending to produce an increased pressure is at a maximum. This latter method is probably the way most of the anti-cyclones seen on our weather maps are produced; and after they have thus been produced they may react, as has previously been shown, in originating new storms, or deflecting the course, of those already produced. The first few causes given above

Ferrel has shown may, under proper conditions, produce a diminished instead of an increased pressure; but I give them because they are usually thought to produce an increased pressure. The subject I think needs farther investigation from an inductive standpoint.

Anti-cyclones tend to move towards the side on which the forces in action tend to produce an increased pressure; and away from the side on which the forces in action tend to produce a diminished pressure. 1st. Since the causes which tend to produce anti-cyclones are ever tending to move toward the east, anti-cyclones must tend to move in the same direction. 2d. Anti-cyclones tend to approach one another because the outward movement of the air tending to diminish the pressure is less in the area beween them than on the opposite side.—The reason why anti-cyclones remain almost stationery in Europe is perhaps because the tendency to move toward the east is counterbalanced by the tendency to move toward the great, permanent Atlantic cyclone. 3d. Anti-cyclones tend to move toward the south because, as shown by Ferrel, the centrifugal force of the air arising from the earth's rotation tends to diminish the pressure least rapidly on the south side of the cyclone.

Storms and anti-cyclones here have been treated as if they were distinct phenomena, but as foreshadowed in the view of Ferrel, they are in one aspect a single phenomenon. Whatever action destroys the equilibrium of the air produces at the same instant equivalent areas of high and low pressure; and it is no more proper to say that the low pressure is the primary result, and the high pressure the secondary result, than to say the opposite. Areas of minimum and maximum pressure are the essential characteristics of storms and anti-cyclones, and we can no more conceive of an area of minimum pressure, without an accompanying equivalent area of maximum pressure, than we can conceive of one pole of a magnet without the other, or of a manifestation of positive electricity without an equivalent manifestation of negative. The phenomenon I think is but an example of that dual aspect of nature which meets us on every hand.

What I have tried to bring clearly in view by the remarks appended to this summary of Loomis' papers is the fact that all of the phenomena of storms and anti-cyclones, their existence and their movements, and hence, indirectly all of the changes in the winds and weather, can be traced directly and completely to differences in the pressure of the atmosphere; and that these differences of pressure in producing the various results act through well-known physical laws. Whether we can trace these differences of pressure, as has long been maintained, directly and entirely to differences of temperature, as the primary cause I think needs farther investigation, and furnishes a problem for the future. In our present state of knowledge it seems to me most probable that differences of pressure are the result of a variety of causes.

H. HELM CLAYTON.

[TO BE CONTINUED.]

CONNECTION BETWEEN METEOROLOGY AND TERRESTRIAL MAGNETISM.

PART III.

The more permanent form of secular Terrestrial Magnetism, apparently connected with geothermal electricity downward to the invariable stratum in the earth's crust, was discussed in Part I. Part II treated of Solar Diurnal Variation and of the places presenting the double type of phenomena: according, in our summer, with the movement in the northern hemisphere; but, in the summer of the southern hemisphere, following the daily march of the needle usual in that portion of our globe. We are now prepared to examine and test by experiment the causes which may have produced the anomalies in the Siberian oval, where, in the interior of the oval, western declination, as high as 5°, occurs, gradually decreasing until it becomes zero around the oval, outside of which the declination is east, up to the Caspian agonic. We shall also see how far the same class of experiments will explain the analogous oval in the southern Pacific, where the outside of the loop is an isoclinic of 8° E., forming an extended oval in the ocean and returning within

itself to intersect near the Gulf of Panama, thence descending to South America. Outside of this oval eastern variation increases, while inside it decreases probably to zero near the centre.

These phenomena can be reproduced on the artificial electric-globe, described in Part I. Giving to the wooden globe, by means of battery No. 1, what we have been terming permanent magnetism, so that a magnetic needle carried around it will exhibit the declination somewhat as given in Guyot's Phy. Geog.; and then coiling an insulated wire in an oval representing the area occupied in Siberia and China, we can produce, by connecting that coil with battery No. 2, the anomalous western declination, with zero outside or all around the coil, provided, that coil, as it emanates from the + pole of the battery is wound in a sinistrorsal oval, returning to the minus pole.

By keeping the portion of the coil which is supposed to be at the Phillipine Islands, *elevated*, and holding the magnetic needle (on a sewing needle thrust through cork) some distance above the centre, we obtain 5° W. variation; and with care to bring the plane of the magnetic needle to coincide with the plane of the coil, we find an agonic area, all around the oval or coil.

Inference.

It seems probable that the electric current, which we endeavored to imitate, has been generated as the result of correlation, or conversion of part of the heat into electricity, when it reaches a great continent, and a relatively better conductor of heat, after traversing over eight thousand miles of ocean, flowing along the worse conductor, namely, the Japan Sea to the cold regions of Yakutsk, &c., returning thence by way of Lake Baikal.

Anomalous Oval in South Pacific and Inferences.

Here we have the heat phenomena and conducting power reversed; the sun has traversed a warmed, immense continent, with only the intervention of the Atlantic, and reaches the eastern shore of the great Pacific Ocean. Following the worse conductor of heat, a dextrorsal electric current, therefore runs from the heated surface near the Mexican and Central American

regions toward the cold, antarctic currents, at a depth perhaps of 3–4 miles, judging from the data furnished by the "Challenger" of the invariable stratum temperature in those seas. By coiling, on the southern hemisphere, insulated copper wire runing from the plus pole of battery No. 2, placed opposite the equator, and winding thence that coil dextrorsally, to return to the minus pole of the battery, after crossing the initial wire, we imitate what appears to take place in the electrical currents of the S. Pacific. But to obtain the exact results, it is necessary that the plane of the horizontal needle be somewhat below the plane of the coil in its northern curve and a little above the plane of the coil in its southern curve. Those conditions being fulfilled we obtain as high as 8° E. variation inside and decreasing to centre, while outside the coil we have increasing eastern declination.

Movements of the Needle at Point Barrow and Toronto, simultaneous; but in opposite directions.

This we can readily imitate if we place two magnetic needles in the relative positions which they would occupy at those two stations; and then gradually approach the south pole of a magnet toward the area which would represent Boothia Felix, the two needles immediately move synchronously but in opposite directions: that at Point Barrow moving to the east while at Toronto it moves west.

Why the Needle is reversed and points South when carried North of Boothia Felix.

Ampère has shown that every coil or solenoid of insulated copper wire, when traversed by electricity, exhibits the properties of a magnet: attracting or repelling according to the direction of the electrical current at the extremities of each solenoid; the tendency or law being to bring separate currents to flow in the same direction.

Thus the earth can readily be seen to be in the condition of a sinistrorsal solenoid, the phenomena observable being only repeated on a wooden globe when the environing wire runs from the plus pole of the battery to about latitude 70° N. and thence coils from E. to W. until it reaches the S. latitude of 70°, and

thence runs to the minus pole. Consequently, as long as we present the needle *above* or more correctly, *outside*, these currents, the circuit around that magnetic needle being dextrorsal, the current on the underside of that magnetic needle or solenoid running from E. to W. corresponds with the current on that part of the earth's surface which is traversed by the needle. But as soon as we are *inside* the earth's coil or solenoid, viz: when we pass to Boothia Felix, which is one of the foci of an oval in which, at about the Arctic circle, as we have seen, a sinistrorsal current is circulating, then a reversal of the needle is necessary in order to bring that equivalent of a dextrorsal solenoid to have its upper circuit correspond with the geothermal currents along the north coasts of North America, while the needle's lower circuit-flow corresponds also with the same geothermal current traversing the north shore of Asia and Europe.

Recapitulation or Summary.

1. The more permanent form of declination and inclination seems due to geothermal currents of electricity encircling the entire globe as far as 70° of N. and S. latitude (at the invariable temperature depth of each locality) and is therefore connected with *vertical* distribution. The secular change, while, perhaps immediately due to the electrically environed horizontal needle seeking the *coldest superficies*, is probably remotely due to cosmic causes.

2. The Solar Diurnal variation is effected, not by geothermal currents encircling the globe, but by atmothermal currents of electricity accompanying the atmosphere from the tropics, in the higher regions, to the poles; and returning in part with the lower strata of air partly perhaps in the earth's superficial crust, thus giving occasion for storms of lightning between the clouds and earth.

3. The double type apparently takes place at stations near the climatic equator, which corresponds closely with the equator of intensity.

4. The peculiarities in the Siberian oval seem due to a sinistrorsal current of electricity, when the sun's heat is transferred

from water to land. Those of the south Pacific require for explanation the supposition (when the heat passes from land to water) of a dextrorsal current of electricity, superficial or elevated near the Bay of Panama, deep-seated or depressed in the Antarctic Ocean.

5. The reversal of the needle within the Arctic and Antarctic regions can be explained by Ampère's law of currents, according to which solenoids, free to move, attract and repel each other.

RICHARD OWEN.

NEW HARMONY, IND., Oct. 14, 1886.

CAUSATION OF PNEUMONIA.*

Employing the data collected in the office of the Michigan State Board of Health, relative to the sickness of pneumonia, and the coincident meteorological conditions in Michigan, more especially during the eight years, 1877–84, I find that certain meteorological conditions are so uniformly associated with sickness from pneumonia, as to make it appear that they bear a causal relation in that disease. The atmospheric condition which is most closely associated with pneumonia, is the night ozone; but, although it is, perhaps, one factor, the manner in which it is associated does not indicate that it is always the controlling factor in the causation of pneumonia. Besides, the amount of ozone is, to a great extent, controlled by the temperature; therefore, I think ozone is not a primary cause. The velocity of the wind has rather close relations to the disease. Variations in atmospheric pressure appear to have influence in the causation of pneumonia. Relative humidity of the atmosphere has apparent relations to the disease in some months, but it also depends largely upon the atmospheric temperature. Absolute humidity of the air has very close relations to pneumonia, and in such manner as to indicate a causal relation. That condition of the air, however, is, so far as relates to outdoor air,

* Abstract of a paper by Dr. Henry B. Baker, before the Am. Clinic Association. Reprinted from the *Boston Medical and Surgical Journal.*

almost wholly controlled by the temperature. Finally, the curves representing the average temperature uniformly bear a very close relation to sickness from pneumonia; and the curves representing sickness follow uniformly at such a period after the temperature curves, as to make it seem certain that the sickness is, directly or indirectly, caused by a comparatively low temperature.

So far, the result is only to prove, in a scientific manner, the truth of more or less widespread beliefs since the time of Hippocrates. But what follows may render this contribution more acceptable. The difficulty in the way of accepting the hypothesis, has been to understand how it is possible for cold to cause pneumonia. Thus, Professor Rindfleisch has said: "Even when based upon some unequivocal observations, we have proclaimed the taking cold as the common cause (of croupous pneumonia), there has yet, by this, no insight been obtained into the process of taking cold. For what has the partial refrigeration of the outer skin to do with the inflammation of an interior organ?" The key to this "insight" which Professor Rindfleisch has said is wanted, has seemed to me to be the fact that the "refrigeration" is not so much of the "outer skin" (which is mostly covered by clothing), as it is of that inner skin—the mucous lining of the lungs and air-passages, and which we are liable to forget is so extensive—amounting as it does, according to Professor Dalton, to about 1,400 square feet of surface, in an ordinary adult person. We are also liable to forget the quantity of vapor of water constantly being taken out of the body by way of the lungs; and my tables show that the quantity of vapor exhaled in excess of that inhaled, is much greater in January than it is in July, in Michigan, because the quantity which enters the lungs with the air inhaled differs greatly, according as the air is, or is not, saturated with vapor, and especially, according to the temperature at which the air is inhaled. The higher the temperature (within ordinary limits), the greater the amount of vapor of water it will contain; thus, according to Professor Guyot's tables, based upon experiments by Reginault, a cubic foot of air at the temperature of zero, Fah., if saturated with vapor of water, con-

tains five Troy grains; at the freezing point, it contains two grains; at 70° F., it contains eight grains; at 98° F., it contains 18.69 grains. Thus the absolute humidity of the air is controlled, as to its maximum, by the temperature of the air. The air exhaled from the lungs has been in constant contact with moist surfaces throughout its passage into, and out from the lungs; it is therefore probably nearly saturated with vapor of water, and at a temperature not far from 98° F. Assuming this, each cubic foot of air exhaled contains 18.69 grains of water; assuming eighteen respirations per minute, of twenty cubic inches of air each, there will be exhaled daily, 11.68 Troy ounces of water.

This is not as much, by four or five ounces, as is stated by some physiologists, but it is convenient to have a standard arrived at, by means the same as those with which we must deal in studying the influence of meteorological conditions, so I continue to employ this method and standard. The absolute grains of vapor in each cubic foot of the atmosphere at any given place and time, are ascertained by means of the wet-bulb and dry-bulb thermometers, and the use of tables. Knowing the "absolute humidity" of the atmosphere for every day in each year, as we now do in Michigan, it is easy to compute the quantity of vapor inhaled daily at each season of the year, assuming, as above, eighteen respirations per minute of twenty cubic inches of air each. This, subtracted from the 11.68 ounces exhaled, gives the excess of moisture exhaled over that inhaled. Cold air is, as we have seen, always dry air, and whenever air is warmed, as it is in the lungs, its capacity to retain vapor of water is increased, and its demand for water is great. Thus when warm air saturated with water is inhaled, one effect is to lessen the passage of fluids from the blood into the air-cells and air-passages; when the air inhaled is cold and dry, an increased quantity of fluids must pass from the blood into the air-cells, in order to keep them in the normal moist condition.

The fluid which constantly passes from the blood-vessels into the air-cells, contains some of the salts of the blood, and such as are volatile, will pass out with the vapor exhaled at every breath; but such salts as chloride of sodium will not readily pass

off with the vapor, the usual mode of preparing salt from brine being by the evaporation of the water therefrom. For many years, it has been known that chloride of sodium, which is found in the urine of healthy persons, is absent during the onward progress of pneumonia, and reappears in the urine when the patient is convalescing. For several years, I tried to obtain such analyses of sputa and lungs of persons dead from undoubted pneumonia, and comparisons with sputa and with lungs of persons who did not have pneumonia, as would show whether it was as I supposed—that during the onward progress of pneumonia, the chloride of sodium passed from the blood into the air-cells, and accumulated there, because it did not so readily pass off as did the vapor of water. However, we are not left to conjecture or hypothesis as to the course which chloride of sodium takes, when, during the onward progress of pneumonia, it disappears from the urine. In Vol. XXXV, of the Transactions of the Royal Medical and Chirurgical Society of London, published in 1852, is a paper by Lionel Smith Beale, wherein he shows, by such analyses as those I have outlined, showing the chemical composition of the sputa and of the lungs, that the chlorides which, during pneumonia, disappear from the urine, do appear in the sputa and in the air-cells of the lungs at such times.

The meteorological and other statistics which I have collected, show that at such times as pneumonia is most caused, there is an unusual demand upon the air-cells for fluids; their function, in this respect, is unusually taxed. Passing into the air-cells with the fluids, are certain salts which do not pass out with the vapor; this is shown by *a priori* evidence, and also by the analyses by Dr. Beale. The salt which accumulates is an irritant.

It has been held that the extraordinary stimulation of an ordinary function of an organ or part of the body, leads to the congestion, and even to inflammation, of that part.

If this be accepted, the causation of pneumonia is now, perhaps, sufficiently shown.

There are, however, certain facts concerning pneumonia which to my mind can now be more fully explained than is done by the foregoing. Prominent facts in the pathology of pneumonia are those which relate to the fibrinous exudate in the air-cells.

Changes in the blood pressure do not seem to fully account for all of them. The curve for atmospheric pressure does not seem to have uniformly quantitative relations to pneumonia. One of my diagrams shows that the average daily *range* of the barometer has such relations as to indicate a possible causal relation. It may be noted, in passing, that in albuminuria there is, as in pneumonia an exudation of unformed material which is not subsequently organized. Speaking of the diseases most associated with pneumonia, Dr. Sturges says: "Thus it will be seen from the appendix that renal disease figures largely among the preëxisting morbid conditions of the individuals enumerated." He also says: "It appears upon calculation that pneumonia in kidney disease is most frequent in the so-called amyloid or waxy degeneration. According to Dr. Dickinson the marked tendency to inflammation which characterizes this change is seen most conspicuously in the lungs, and next, most often the pleura."[2]

I have shown how, through the inhalation of cold, dry air, the exudation of fluids into the air-cells is increased; and how, by the unusual evaporation of that fluid, an unusual quantity of the chloride of sodium accumulates in the air-cells. It remains to point out how, through the influence of that chloride of sodium in the air-cells, the exudation into them of the albuminous constituents of the blood serum is probably favored. Prof. Dalton, in his Physiology says: "But a substance like albumen, which will not pass out by exosmosis toward pure water, may traverse a membrane which is in contact with a solution of salt. This has been shown to be the case with the shell-membrane of the fowl's egg, which if immersed in a watery solution containing from three to four per cent. of sodium chloride, will allow the escape of a small proportion of albumen. Furthermore, if a mixed solution of albumen and salt be placed in a dializing apparatus, the salt alone will at first pass outward leaving the albumen; but after the exterior liquid has become perceptibly saline, the albumen also begins to pass in appreciable quantity."

It seems significant that two organs in which an albuminous exudation is so marked as in the kidneys and the lungs should

[2] Natural History of Pneumonia, Sturges, p. 82.

both be so constituted as that these facts relative to the exosmosis of albuminous substances should be applicable; because chloride of sodium is normally excreted by the kidneys, and as it passes by osmosis with extreme facility, the first beginnings of the urine would naturally contain it, so that when the blood is unusually saline the urine in the uriniferous tubules may be sufficiently saline to induce the exosmosis of albumen from the blood-vessels. But while this may occur in the kidney, one condition seems to make it more probable in the lungs, because in the lungs, through the constant evaporation of the fluids exuded, the salinity of the remaining portion may be constantly increased.

Whether the ultimate fibrinous character of the exudate in the lungs is due to the blood placques, or is a result of the oxidation of the albumen otherwise induced, before or after the oxidation, it may be well to notice that the diagrams that I present show close relations between the curves for atmospheric ozone and pneumonia. An albuminous or a fibrinous exudate is a favorable situation for the reproduction of micro-organisms. Whether in pneumonia there are or are not such low organisms as the "pneumo-coccus of Friedländer, the statistics which I present show that the causation of the disease is absolutely controlled by the meteorological conditions. The facts that one attack does not protect from another, and that persons who have had it are more likely to have it again, are against its being a specific disease, but not against the mode of causation which I have pointed out.

In statistics the variety of pneumonia is not usually stated. The data which I present seems to prove that in Michigan it is all, or nearly all, of one kind, causally, otherwise it would not have absolutely quantitative relations to the temperature as it is shown to have in the accompanying diagram. The reason why that diagram shows smoother curves than the others, is I think, because the details of the observations and reports were more accurately attended to. The meteorological observers were supplied with standard thermometers, the stations were representative of the area in which the sickness was, the reports of sick-

ness were made weekly by leading physicians in active practice, and the compilation has been done with great care to learn the exact truth.

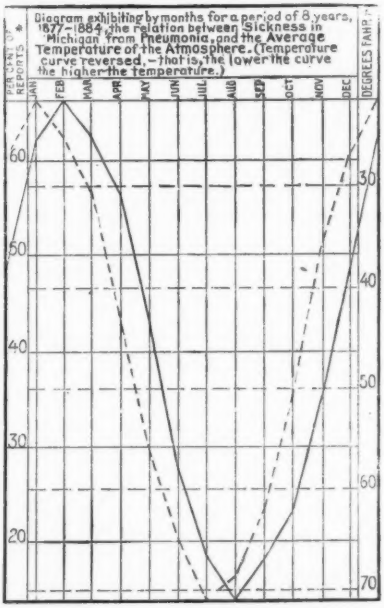


Diagram exhibiting by months for a period of 8 years, 1877-1884, the relation between Sickness in Michigan from Pneumonia, and the Average Temperature of the Atmosphere. (Temperature curve reversed, — that is, the lower the curve the higher the temperature.)
PER CENT OF * REPORTS
DEGREES FAHR.
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
60
50
40
30
20
30
40
50
60
70

Sickness from Pneumonia——— Average Temperature — — — —

Whenever the views here presented shall have been accepted, numerous questions will arise,—as to the diet,—favorable to keeping the blood in the condition to best resist the tendency to pneumonia, as to methods of treatment, whether by warm, moist air, and especially as to how best to control the condition of the air breathed by persons generally as to lessen the danger of their contracting the disease. One lesson seems obvious, namely, the importance of moistening all air which requires to be warmed, in houses, offices, public buildings, and wherever such conditions of the air inhaled can be controlled.

---

*Of all reports received, the per cent. which stated the presence of pneumonia then under the observation of physicians reporting.

ADDITIONAL CURRENT EVENTS.

THE DEATH OF GENERAL HAZEN.—We regret to have to record the death of General Hazen, the chief Signal Officer. The news of his death reaches us just as we are going to press. The efficiency of the Signal Service was much increased during his administration of its affairs and he deserves especial credit for having re-organized its more purely scientific requirements, as opposed to those which were practical. The scientific study of meteorology had General Hazen's support and, as the influence of the chief signal officer is almost autocratic in this science in this country, the influence of this support was felt by all students of the subject, even those not connected with the service over which he presided.

A PROPOSED SCHOOL OF HYGIENE.—It is now proposed to establish a school of Hygiene at the University of Michigan. This is a new departure and its initiation is due to the State Board of Health, and especially to Prof. V. C. Vaughan. Such a school would include in its curriculum climatological studies, air analyses, ventilation, and other subjects bearing more or less directly on Meteorology. The work would fall under the direction of Dr. Vaughan and would be well done. It is to be hoped that the legislature will authorize the necessary expenditure.

THE STATE SIGNAL SERVICE.—We note that both Governor Alger, (the outgoing Governor), and Governor Luce, (the incoming one), refer in their messages to the Michigan legislature, in appreciative terms, to the proposed new service. The service asks for aid from the legislature. It is to be hoped that it will get the aid needed, for a little money expended in the service would be of great assistance. There is probably no way in which the legislature could expend a small sum more profitably.

THE SCIENTIFIC AMERICAN; published by the great patent agency firm of Munn & Co., New York, is the most practically useful publication of the kind in the country. Indeed, it occu-

pies a field distinctively its own. Not alone for the machinist, manufacturer, or scientist, but it is a journal for popular perusal and study. It is the standard authority on scientific and mechanical subjects. It is placed at a very low rate of subscription, $3 per annum, which places it within the reach of all.

By an oversight the proof of Mr. Rotch's article on the "Sonnblick Observatory" in the December JOURNAL, was not corrected, and several errors were allowed to appear in it. We make this explanation to relieve the minds of those who may have been mystified by some of the wrongly printed sentences.

BAILEY'S 30 INCH COSMOSPHERE

With metal coverings and constellation figures is worth "all the Globes and Tellurians ever constructed for making plain the causes of Celestial phenomena." "The constellations and their motions are shown in correct position and not reversed as in the ordinary Celestial globes."

"The changes of seasons and varying length of days are clearly shown." "An indispensable help in teaching Astronomical facts."

Correspondence solicited with one *good teacher* in each State who has the ability to sell goods and time to devote to it. Address

MICHIGAN SCHOOL FURNITURE CO.,
Northville, Wayne Co., Mich.

EVERY Bookkeeper, Banker, Broker, Guardian, Judge, Lawyer, Trustee and all concerned in the computation of interest, the division and settlement of estates, the negotiation of securities, or the borrowing and lending of money SHOULD SEND FOR A CIRCULAR describing "Watson's Interest, Discount and Investment Tables," the great work of the late Prof. James C. Watson, formerly Director of the Observatories and Professor of Astronomy at the Universities of Michigan and Wisconsin, and Actuary of the Michigan Mutual Life Insurance Company.
REGISTER PUBLISHING CO., Ann Arbor, Mich.

TO ADVERTISERS!

FOR a check for $20 we will print a ten line advertisement in One Million issues of leading American Newspapers and complete the work within ten days. This is at the rate of only one-fifth of a cent a line, for 1,000 Circulation! The advertisement will appear in but a single issue of any paper, and consequently will be placed before One Million different newspaper purchasers;—or FIVE MILLION READERS, if it is true, as is sometimes stated, that every newspaper is looked at by five persons on an average. Ten lines will accommodate about 75 words. Address with copy of Adv. and check, or send 30 cents for Book of 176 pages.
GEO. P. ROWELL & CO., 10 SPRUCE ST., NEW YORK.

We have just issued a new edition (the 161st) of our Book called "Newspaper Advertising." It has 176 pages, and among its contents may be named the following Lists and Catalogues of Newspapers:—

DAILY NEWSPAPERS IN NEW YORK CITY, with their Advertising Rates.

DAILY NEWSPAPERS IN CITIES HAVING more than 150,000 population, omitting all but the best.

DAILY NEWSPAPERS IN CITIES HAVING more than 20,000 population, omitting all but the best.

A SMALL LIST OF NEWSPAPERS IN which to advertise every section of the country: being a choice selection made up with great care, guided by long experience.

ONE NEWSPAPER IN A STATE. The best one for an advertiser to use if he will use but one.

BARGAINS IN ADVERTISING IN DAILY Newspapers in many principal cities and towns, a List which offers peculiar inducements to some advertisers.

LARGEST CIRCULATIONS. A complete list of all American papers issuing regularly more than 25,000 copies.

THE BEST LIST OF LOCAL NEWSPAPERS, covering every town of over 5,000 population and every important county seat.

SELECT LIST OF LOCAL NEWSPAPERS, in which advertisements are inserted at half price.

5,493 VILLAGE NEWSPAPERS in which advertisements are inserted for $41 a line and appear in the whole lot—one-half of all the American Weeklies.

Sent to any address for THIRTY CENTS.

History of the University of Michigan,

by MISS LIZZIE M. FARRAND. 300 pp., cloth, heavy paper. Price, $1.00. A few remaining copies of present edition at 60 cents post paid.
REGISTER PUBLISHING CO.,
Ann Arbor, Mich.

After Forty years' experience in the preparation of more than One Hundred Thousand applications for patents in the United States and Foreign countries, the publishers of the Scientific American continue to act as solicitors for patents, caveats, trade-marks, copyrights, etc., for the United States, and to obtain patents in Canada, England, France, Germany, and all other countries. Their experience is unequaled and their facilities are unsurpassed.

Drawings and specifications prepared and filed in the Patent Office on short notice. Terms very reasonable. No charge for examination of models or drawings. Advice by mail free.

Patents obtained through Munn & Co. are noticed in the **SCIENTIFIC AMERICAN**, which has the largest circulation and is the most influential newspaper of its kind published in the world. The advantages of such a notice every patentee understands.

This large and splendidly illustrated newspaper is published **WEEKLY** at $3.00 a year, and is admitted to be the best paper devoted to science, mechanics, inventions, engineering works, and other departments of industrial progress, published in any country. It contains the names of all patentees and title of every invention patented each week. Try it four months for one dollar. Sold by all newsdealers.

If you have an invention to patent write to Munn & Co., publishers of Scientific American, 361 Broadway, New York.

Handbook about patents mailed free.

STANDARD THERMOMETER.

LEGIBLE.

5 inch Dial.

$3.00.

ACCURATE.

8 inch Dial.

$4.00.

(Metallic.)

Special Thermometers for Meteorologists with or without Telemeter attachments

AGENTS:

THE FAIRBANKS SCALE HOUSES

In the principal cities of the United States.

Medical and Surgical Sanitarium, Battle Creek, Michigan.

THE LARGEST SANITARIUM IN THE WORLD.

This Institute has for many years enjoyed an increasing patronage from all parts of the United States and Canada, during which time more than 10,000 Patients have enjoyed the benefits of its unrivaled facilities for the treatment of all forms of Chronic Diseases, including special departments for the Eye, Ear, Throat, and Lungs, together with diseases peculiar to each sex. Every Remedial Agent of Known Value is Employed.

The managers have spared no expense to perfect the appliances of the Establishment to the highest degree, and regardless of cost; and a personal acquaintance with the leading Sanitariums of both this country and Europe, enables us to say that no where else in the world can the invalid in search of health find so great an assemblage of means and appliances for combating disease as found here.

Address, for circulars and further information, inclosing stamp,

SANITARIUM, Battle Creek, Mich.